

FORM-PTO-1390  
(Rev. 12-29-99)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

027650-936

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)

Unassigned

09/856696

INTERNATIONAL APPLICATION NO.  
PCT/SE99/02175

INTERNATIONAL FILING DATE  
24 November 1999 (24.11.99)

PRIORITY DATE CLAIMED  
25 November 1998 (25.11.98)

TITLE OF INVENTION  
HEAT EXCHANGER

APPLICANT(S) FOR DO/EO/US  
PERSSON, Kjell

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and the PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.  
☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

Publ. Appln. No. WO 00/31489; PCT Forms ISA/210 and IPEA/401; Unexecuted Declaration; Bibliographic Data Sheet.

U.S. APPLICATION NO. (if known) / see 37 CFR 1.50 <b>Unassigned 097/856696</b>	INTERNATIONAL APPLICATION NO. <b>PCT/SE99/02175</b>	ATTORNEY'S DOCKET NUMBER <b>027650-936</b>
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17. <input checked="" type="checkbox"/> The following fees are submitted:				<b>CALCULATIONS</b>	PTO USE ONLY
<b>Basic National Fee (37 CFR 1.492(a)(1)-(5)):</b>  Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... \$1,000.00 (960)  International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... \$860.00 (970)  International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$710.00 (958)  International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... \$690.00 (956)  International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00 (962)					
<b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>					
Surcharge of <b>\$130.00 (154)</b> for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492(e)). 20 <input type="checkbox"/> 30 <input type="checkbox"/>				\$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	6 -20 =		X\$18.00 (966)	\$	
Independent Claims	1 -3 =		X\$80.00 (964)	\$	
Multiple dependent claim(s) (if applicable)			+ \$270.00 (968)	\$	
<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$	1,000.00
Reduction for 1/2 for filing by small entity, if applicable (see below).				\$	-
<b>SUBTOTAL =</b>				\$	1,000.00
Processing fee of <b>\$130.00 (156)</b> for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492(f)). 20 <input type="checkbox"/> 30 <input type="checkbox"/>				\$	
<b>TOTAL NATIONAL FEE =</b>				\$	1,000.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00 (581)</b> per property +				\$	
<b>TOTAL FEES ENCLOSED =</b>				\$	1,000.00
				<b>Amount to be: refunded</b>	\$
				<b>charged</b>	\$

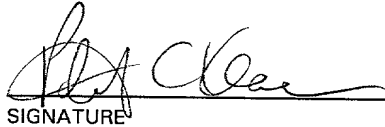
- a. ☐ Small entity status is hereby claimed.
- b. ☒ A check in the amount of \$ 1,000.00 to cover the above fees is enclosed.
- c. ☐ Please charge my Deposit Account No. 02-4800 in the amount of \$ \_\_\_\_\_ to cover the above fees. A duplicate copy of this sheet is enclosed.
- d. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-4800. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

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 BURNS, DOANE, SWECKER & MATHIS, L.L.P.  
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Date : May 25, 2001

  
 SIGNATURE

for Robert S. Swecker  
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19,885  
 REGISTRATION NUMBER

HEAT EXCHANGER

## TECHNICAL FIELD

5 The present invention relates to a heat exchanger of the type which includes a plurality of heat exchanger elements carried by a frame and interconnected to one another in a flow system with a product flow and flow for a heat transfer medium, each heat exchanger element displaying, on the one hand, one or more heat transfer tubes interconnected by means of tube plates to form product flow inserts, and, on the other hand, a casing tube  
10 surrounding the heat transfer tubes, two adjacent product flow inserts being interconnected with one another by means of product pipe bends.

## BACKGROUND ART

15 Heat exchangers, which exist in a multiplicity of types, are employed when the intention is to heat or cool a liquid product, for example with the aid of steam, water or other liquid at different temperatures. Heat exchangers come into use within various process industries and are also common occurrences in the food industries, such as dairies.

20 A well-known type of heat exchanger is the so-called tube heat exchanger which consists of one or more heat exchanger elements which are interconnected with one another in a flow system, with a product flow and a flow for a heat transfer medium. A heat exchanger element substantially consists of one or more heat transfer tubes surrounded by an outer casing tube. The heat transfer tubes are interconnected by means of a tube plate to  
25 form a unit, a product flow insert. Two adjacent product flow inserts are in turn interconnected by means of product pipe bends to form a product flow in order to be able to circulate the product which is to be heated or cooled in the process. The outer casing tubes are also interconnected in order to be able to circulate a heat transfer medium, such as water or other liquid, or steam  
30 or alternatively other gases.

In recent times, attempts have been made to modularise tube heat exchangers of the above-outlined type in order to realise a simpler assembly and to avoid each tube heat exchanger becoming "customised". Such a tube heat exchanger is described in Swedish Patent Specification SE 501 908.

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## OBJECTS OF THE INVENTION

One object of the present invention is to further simplify the modularised tube heat exchanger in order to create the possibility of competing with the plate heat exchanger which are common on the market and are considerably cheaper.

A further object of the present invention is to realise a tube heat exchanger which, despite its compact construction, is capable of taking up the thermal expansions which always occur in heat exchangers.

Yet a further object of the present invention is to realise a tube heat exchanger which is economical to manufacture and which is simple to install and maintain.

## SOLUTION

These and other objects have been attained according to the present invention in that the heat exchanger of the type described by way of introduction has been given the characterizing feature that two adjacent casing tubes are interconnected by means of a connection member and that the tube plates constitute a part of the frame, flexibly interconnected with adjacent tube plates.

Preferred embodiments of the heat exchanger according to the present invention have further been given the characterizing features as set forth in the appended subclaims.

## BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

One preferred embodiment of the heat exchanger according to the present invention will now be described in greater detail hereinbelow, with particular reference to the accompanying Drawings. In the accompanying Drawings:

Fig. 1 is a side elevation of a heat exchanger according to the present invention;

Fig. 2 is a side elevation of a part of a heat exchanger;

Fig. 3 is a side elevation, partly in section, of a product pipe bend;

Fig. 4 is a side elevation, partly in section, of a part of a heat exchanger element;

Fig. 5 is a plan view of a tube plate;

Fig. 6 is a plan view of a connection profile; and

Figs. 7-9 show different end elevations of heat exchangers.

The accompanying Drawings show only those parts and details essential to an understanding of the present invention.

## 5 DESCRIPTION OF PREFERRED EMBODIMENT

Figs. 2 and 3 show the construction of the heat exchanger. A tube heat exchanger according to the present invention consists substantially of one or more heat exchanger elements 1. The heat exchanger normally consists of a number of these heat exchanger elements 1, interconnected with one another in a flow system. A heat exchanger element 1 consists of an outer casing tube 2 which surrounds one or more heat transfer tubes 3. The heat transfer tubes 3 are interconnected to one another at each end of the tubes 3 by means of a tube plate 4. A number of heat transfer tubes 3 with a tube plate 4 at each end constitutes a product flow insert 5. The casing tube 2 is, in both ends, welded to each respective tube plate 4.

Fig. 1 shows a number of heat exchanger elements 1 interconnected to form a heat exchanger. The heat exchanger has a flow for product, which is shown by means of white arrows, and a flow for a heat transfer medium, which is shown by black arrows. The heat transfer medium is to heat or cool the product, depending upon the process which is desired. The heat transfer medium may consist of water or other liquid of different temperature, or alternatively of steam or other gas. A heat exchanger according to the present invention may also be employed regeneratively, i.e. product is employed in both of the flows so that an already heated product heats the incoming cold product, and vice versa.

The product flow is circulated in the heat transfer tubes 3 which constitute the major part of the product flow inserts 5. Two adjacent product flow inserts 5 are interconnected by means of a product pipe bend 6, in that the product pipe bend is secured with a flange union in two adjacent tube plates 4. The product pipe bend 6 is preferably of elliptical cross section centrally between two product flow inserts 5, in point 7, and of circular cross section in both its ends. Alternatively, the product pipe bend 6 may be of circular cross section throughout its entire length. An elliptical product pipe bend 6 in accordance with the foregoing is described in detail in Swedish Patent Application SE 9703865-7.

The flow for the heat transfer medium is circulated through the casing tubes 2. In the proximity of both of their ends, the casing tubes 2 have a circular aperture 8 in the casing surface with a collar 9. The collar 9 corresponds with a connection member 10. The connection member 10 which substantially consists of a straight tube length, is bevelled in both its ends and provided with a gasket or O-ring 11. The collars 9 abut against the O-rings 11 in both ends of the connection member 10 and constitute a tight and, to some degree, a flexible union.

A tube plate 4 which constitutes a part of a product flow insert 5, is shown in Fig. 5. The plate 4 has modular adapted outer dimensions and, in its four corners, is provided with grooves 12. The grooves 12 correspond with a coupling profile 13 which is shown in Fig. 6. The coupling profile 13 is substantially cruciform. A coupling profile 13 may unite two, three or four tube plates 4.

In that the tube plates 4 in a heat exchanger are placed closely adjacent one another united by coupling profiles 13, there will be obtained a stable unit which constitutes a part of the frame of the heat exchanger. Various ways of placing four heat exchanger elements 1 are shown in Figs. 7-9. The heat exchanger elements 1 are placed on a lower frame section 14 with adjustable feet 15. The lower frame section 14 has grooves 16 corresponding to the grooves 12 in the tube plates 4. The tube plates 4 are locked against the lower frame section 14 by means of coupling profiles 13.

As a result of the design and thickness of the coupling profiles 13, each individual heat exchanger element 1 may move in its longitudinal direction. This is a necessity, since the heat exchanger elements are subjected to powerful thermal expansion. The connection members 10 may also move laterally to some degree and trials have shown that a tight union will be obtained despite oblique inclination against the O-rings 11. The corresponding oblique inclination would not be possible in, for example, a flange union.

As a result of the form of the product pipe bend 5 with an elliptical cross section centrally in the pipe bend 6, a further portion of the heat exchanger will be obtained which is capable of absorbing the thermal stresses in that the product pipe bend 6 is somewhat flexible in its form. A corresponding pipe bend of circular cross section throughout its entire length is not flexible at all.

By employing modular adapted tube plates 4 to which different casing tubes 2 may be connected, and by employing connection members 10 of different heights, there will be obtained a series of tube heat exchangers with different capacities which may be manufactured with a few simple parts. The heat exchanger will be simple to assemble, and service is simplified since it is not necessary to dismantle more than that heat exchanger element 1 which needs to be replaced.

The connection member 10 may be readily dismantled anywhere whatever in a complete heat exchanger, which affords a certain possibility for inspection. This is particularly important when the heat exchanger is employed regeneratively, i.e. when product is run against product. The connection member 10 is easy to maintain since it normally entails that only the O-rings 11 must be replaced. The connection member 10 is also relatively simple to manufacture given that the flexibility in the member 10 gives room for greater tolerances.

In the event of possible crack formation, because of stress corrosion which is a common occurrence in tube heat exchangers with fixed connections between the casing tubes 2, two casing tubes 2 must be replaced. The risk of crack formation in a heat exchanger according to the present invention is reduced in that the connection member 10 may take up a part of the thermal expansion. If crack formation were nevertheless to occur, only one casing tube 2 need be replaced.

As will be have been apparent from the foregoing description, the present invention realises a heat exchanger which is simple and economical to manufacture and which has great possibilities for taking up the thermal expansion which occurs in a heat exchanger.

## WHAT IS CLAIMED IS:

1. A heat exchanger of the type which includes a plurality of heat exchanger elements (1) carried by a frame and interconnected to one another in a flow system with a product flow and flow for a heat transfer medium, each heat exchanger element (1) displaying, on the one hand, one or more heat transfer tubes (3) interconnected by means of tube plates (4) to form product flow inserts (5), and, on the other hand, a casing tube (2) surrounding the heat transfer tubes (3), two adjacent product flow inserts (5) being interconnected with one another by means of product pipe bends, characterized in that two adjacent casing tubes (2) are interconnected by means of a connection member (10); and that the tube plates (4) constitute a part of the frame, flexibly interconnected with adjacent tube plates (4).
2. The heat exchanger as claimed in Claim 1, characterized in that the product pipe bend (6) is of elliptical cross section at the centre of the bend (6).
3. The heat exchanger as claimed in Claim 1, characterized in that the tube plates (4) have grooves (12) in their four corners, said grooves (12) corresponding with substantially cruciform coupling profiles (13).
4. The heat exchanger as claimed in Claim 3, characterized in that the coupling profiles (13) are of a thickness which gives the heat exchanger elements (1) the possibility of moving in their longitudinal direction.
5. The heat exchanger as claimed in Claim 1, characterized in that the connection member (10) consists of a straight tube section with an O-ring (11) in each end.
6. The heat exchanger as claimed in Claim 1, characterized in that the tube plates (4), together with a lower frame section (14), constitute the frame of the heat exchanger.



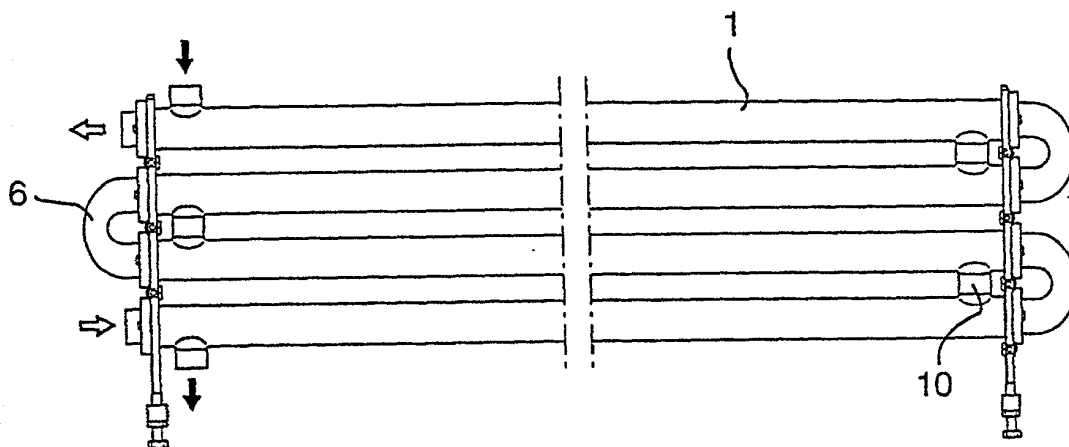


Fig 1

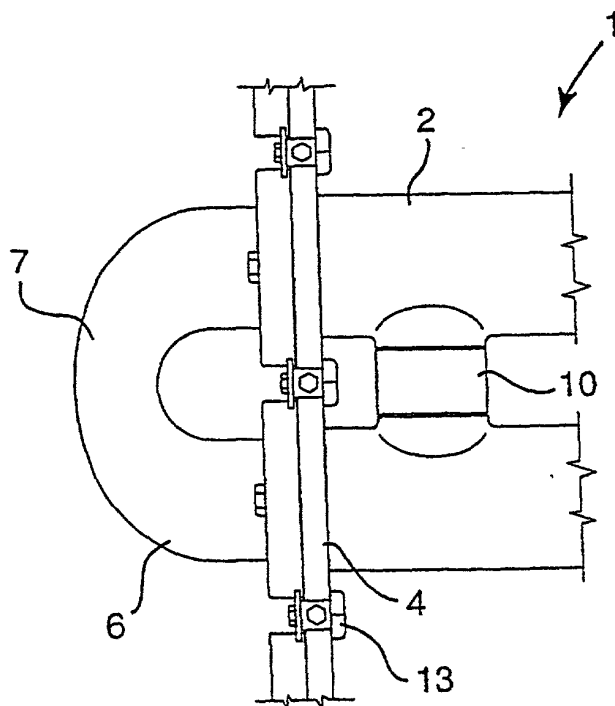


Fig 2

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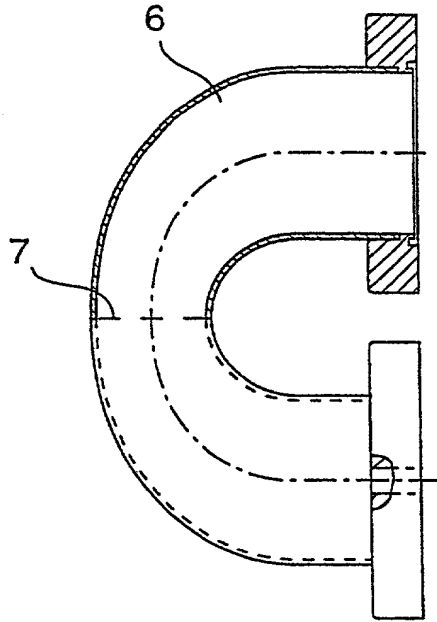


Fig 3

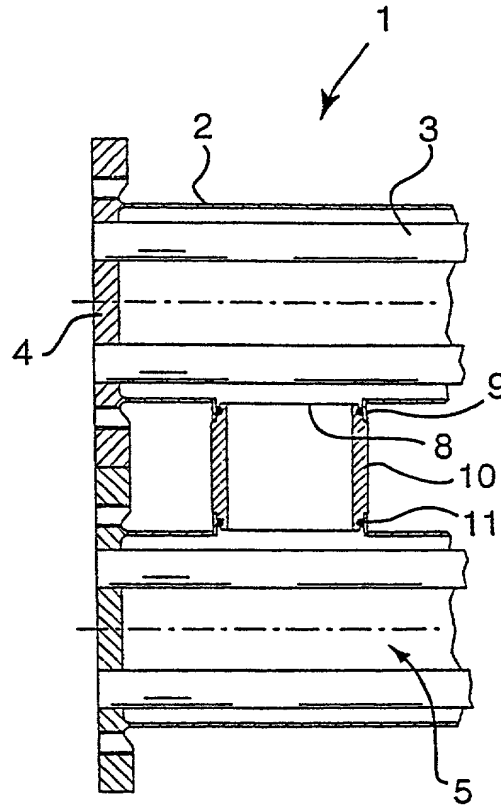


Fig 4

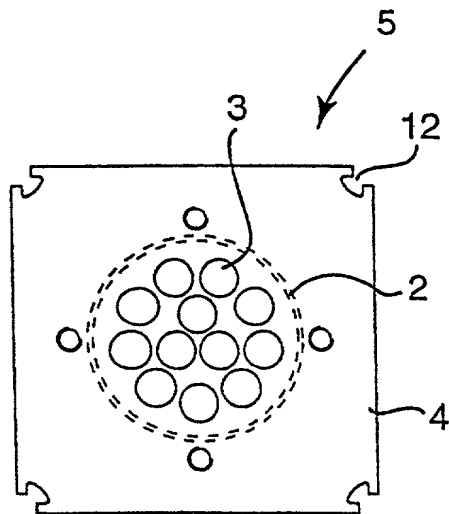


Fig 5

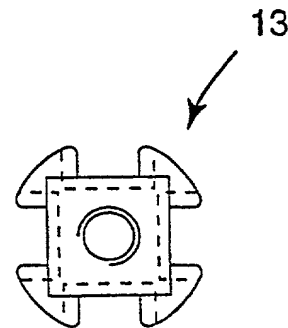


Fig 6

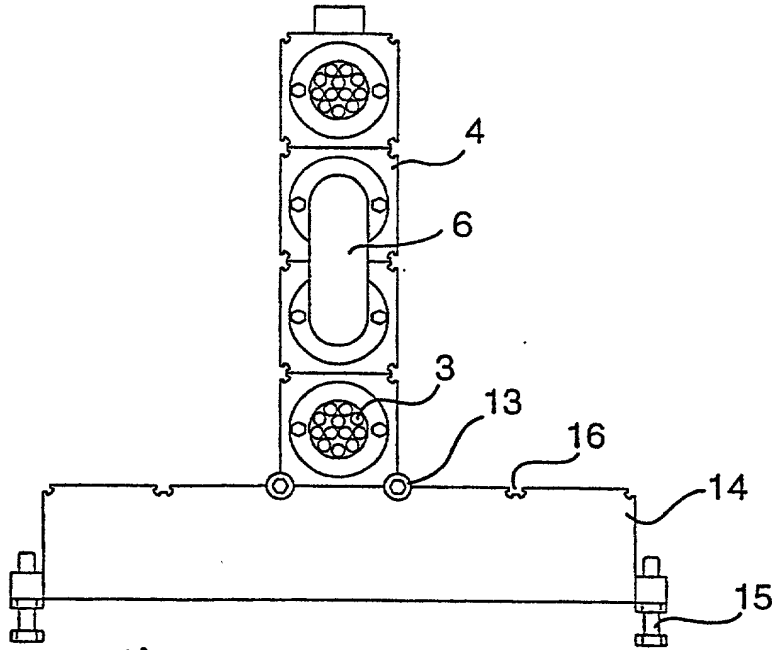


Fig 7

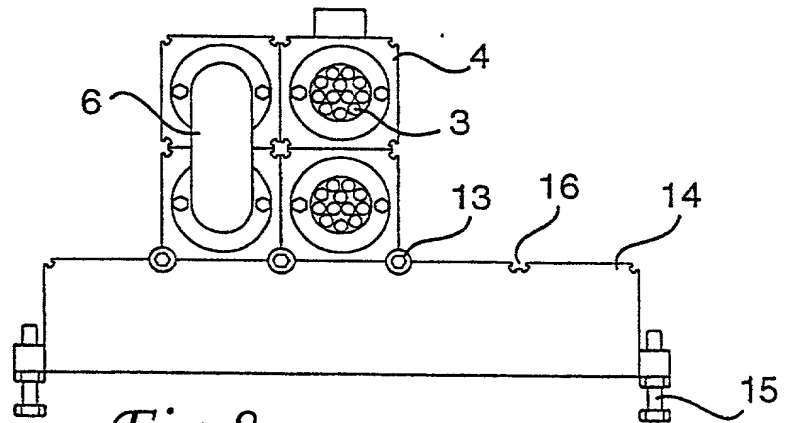


Fig 8

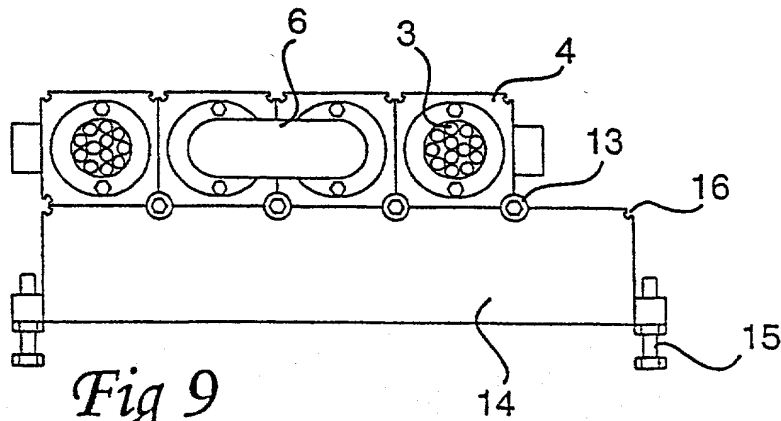


Fig 9

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**COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY**  
(Includes Reference to Provisional and PCT International Applications)

Attorney's Docket No.

027650-936

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

HEAT EXCHANGER

the specification of which (check only one item below):

☐ is attached hereto.

☐ was filed as United States application

Number \_\_\_\_\_

on \_\_\_\_\_

and was amended

on \_\_\_\_\_ (if applicable).

☒ was filed as PCT international application

Number PCT/SE99/02175

on 24 November 1999 (24.11.99)

and was amended

on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(e) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

**PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. §119:**

COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. §119
Sweden	9804037-1	25 November 1998 (25.11.98)	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

\_\_\_\_\_  
(Application Number)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Application Number)

\_\_\_\_\_  
(Filing Date)

**COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (CONT'D)**  
(Includes Reference to Provisional and PCT International Applications)

Attorney's Docket No.

027650-936

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose to the Office all information known to me to be material to the patentability as defined in Title 37, Code of Federal Regulations §1.56, which became available between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. §120:

U.S. APPLICATIONS		STATUS (check one)		
U.S. APPLICATION NUMBER	U.S. FILING DATE	PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.				
PCT APPLICATION NO.	PCT FILING DATE	U.S. APPLICATION NUMBERS ASSIGNED (if any)		

I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:

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Platon N. Mandros	22,124	Teresa Stanek Rea	30,427	Ronni S. Jillions	31,979
Benton S. Duffett, Jr.	22,030	Robert E. Krebs	25,885	Harold R. Brown III	36,341
Norman H. Stepno	22,716	William C. Rowland	30,888	Allen R. Baum	36,086
Ronald L. Grudziecki	24,970	T. Gene Dillahunt	25,423	Brian P. O'Shaughnessy	32,747
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James A. LaBarre	28,632	Michael G. Savage	32,596		
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21839

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Address all telephone calls to: Robert S. Swecker at (703) 836-6620.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (CONT'D)**  
(Includes Reference to Provisional and PCT International Applications)

Attorney's Docket No.

027650-936

1-00 FULL NAME OF SOLE OR FIRST INVENTOR PERSSON, Kjell		SIGNATURE 		DATE 01-08-10
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POST OFFICE ADDRESS Ramshogsvagen 4, S-244 71 Dosiebro, Sweden <i>SEX</i>				
FULL NAME OF SECOND JOINT INVENTOR, IF ANY		SIGNATURE		DATE
RESIDENCE		CITIZENSHIP		
POST OFFICE ADDRESS				
FULL NAME OF THIRD JOINT INVENTOR, IF ANY		SIGNATURE		DATE
RESIDENCE		CITIZENSHIP		
POST OFFICE ADDRESS				
FULL NAME OF FOURTH JOINT INVENTOR, IF ANY		SIGNATURE		DATE
RESIDENCE		CITIZENSHIP		
POST OFFICE ADDRESS				
FULL NAME OF FIFTH JOINT INVENTOR, IF ANY		SIGNATURE		DATE
RESIDENCE		CITIZENSHIP		
POST OFFICE ADDRESS				
FULL NAME OF SIXTH JOINT INVENTOR, IF ANY		SIGNATURE		DATE
RESIDENCE		CITIZENSHIP		
POST OFFICE ADDRESS				
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